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TRISONIC FRUSTUM AERODYNAMIC LOADS STUDY

SEPTEMBER PROGRESS REPORT

Contract NAS8-20121

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FOREWORD

This document reports progress during the period 23 August to 22 September 1965 for the Trisonic Frustum Aerodynamic Loads Study, Contract NAS8-20121. This study is being conducted for the NASA/MSFC Aero-Astrodynamics Laboratory to define parametrically the linear aerodynamic load distributions for cone-cylinder-flare-cylinder configurations in the transonic and low supersonic Mach number regimes. Work under this contract is being performed by personnel at the Huntsville Research & Engineering Center of Lockheed Missiles & Space Company.

SUMMARY

The purpose of the Trisonic Frustum Aerodynamic Loads Study is to establish a set of aerodynamic loads design curves for cone-cylinder-flare-cylinder configurations on a parametric basis. The Mach number range of interest is from 0.7 to 2.0.

A test program being conducted under another contract to provide experimental data for the study is approximately 50% complete. All test results have undergone basic data reduction and are presently available in the form of pressure coefficients. These pressure coefficient data have all been processed by the LMSC/HREC data analysis program for integration to local normal force and have been machine plotted. Slopes have been evaluated by a computer program using a curve fit routine and are being checked against hand-read values. Because of small input errors, about 15% of the data must be re-run in the analysis program.

Scrutiny of shadowgraphs obtained during the completed portion of the test program has revealed that fully turbulent boundary layers were not adequately achieved with the grit trip on the bodies with 15° noses. The influence of the undesired partial laminar boundary layer on the test results is not immediately apparent, but will be studied at some length early in the next phase of testing.

INTRODUCTION

The objective of this study is to develop aerodynamic loads design curves for cone-cylinder-flare-cylinder configurations (Figure 1) in the transonic and low supersonic Mach number regimes. Activity during the preceding period of performance is described in Reference 1. Adequate theoretical methods are not available; hence the study will rely on experimental results to define the desired design curves.

A survey of the literature revealed that relatively few test data are documented which apply to the current study. Consequently, it was found necessary to plan a wind tunnel test program covering the complete spectrum of significant parameters. The program included pressure tests to obtain the data necessary to establish normal force slope distributions and force tests to verify the total forces and moments acquired by the integration of model pressure distribution. The test program is being conducted jointly by LMSC/HREC and NASA/MSFC under another contract in the MSFC 14-inch trisonic tunnel.

DISCUSSION

Efforts for this project are now being devoted to the reduction, preliminary examination and the correlation of test results. At present, about 50% of the planned pressure test data are available. Generally, the data appear to be good, most of the results having been inspected.

Data Reduction

All experimental pressure coefficient data obtained in the first phase of the test program have been machine integrated and plotted. About 15% of the data require re-running in the analysis program because of small input errors.

Screening of integrated pressure data and local normal force gradients has been a continuing effort to determine the most adequate of several curve fit methods for computing the gradients. Present indications are that the third-order least squares curve fit best defines the local normal force variation with angle of attack, except perhaps in isolated regions where local normal shocks are present. In such regions, the applicable angle of attack range of gradients determined from the third-order method is considerably limited.

Boundary Layer Trip Problem

Close examination of shadowgraphs taken of the test configurations with a 15° nose cone reveals that the boundary layer was not tripped at all or was tripped too early with a laminar layer being re-established on the cone throughout the Mach range. This condition probably results from the trip strips being placed too close to the nose tip of the model. The influence of this situation on the data has not yet been determined, but will be investigated in the coming phase of the test program.

Boundary layer trips for the configuration with larger nose cone angles were placed farther back from the cone tip, but no shadowgraphs were taken to examine the quality of the flow for these configurations. It is possible that the trip problem is unique with the 15° nose, but will be examined for other noses in the coming test phase.

Reynolds Number and Porous Wall Effects

Evaluation of the available experimental data indicates that no significant Reynolds number effects were realized in the range of tunnel capability. Application of boundary layer trips also revealed no significant pressure effects, but some question exists yet as to whether or not a fully turbulent boundary layer was attained with the trips. Additional shadowgraph studies will be made to determine the trip effectiveness for all trip installations.

Some differences were noted in the experimental pressure data taken with glass side walls in the tunnel as compared to data taken with porous side walls. The differences are thought not to be large enough to cause significant alterations in shock patterns on the model, but the data with glass walls will not be included in the overall analysis for generation of design curves.

FUTURE WORK

During the coming performance period, work will continue toward evaluation of curve fit methods and data refinement. Shadowgraph information is expected to become available and the effects of the untripped boundary layer on the available data will be determined. Comprehensive data analysis from a parametric standpoint will await the completion and reduction of experimental data from the second phase of the test program.

REFERENCE

1. Hamner, Roger Lee, Trisonic Frustum Aerodynamic Loads Study, August Progress Report, LMSC/HREC A711778, Lockheed Missiles & Space Company, Huntsville Research & Engineering Center, Huntsville, Alabama, 2 September 1965.

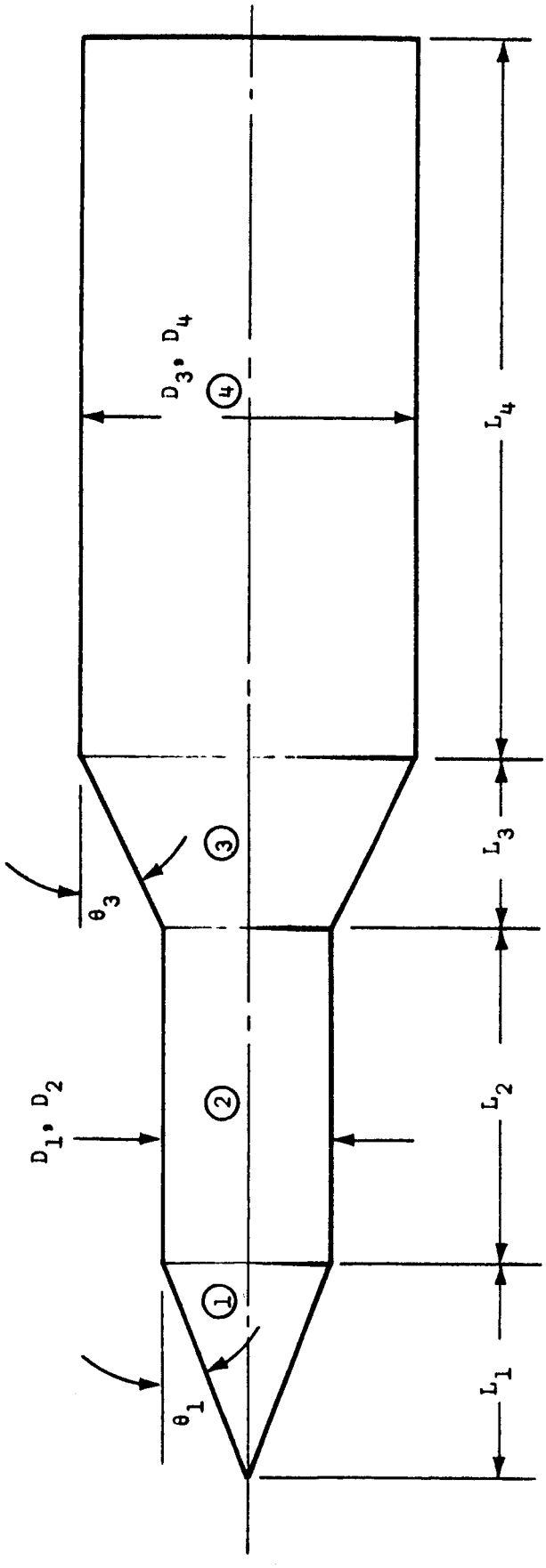

Figure 1 - Configuration Sketch